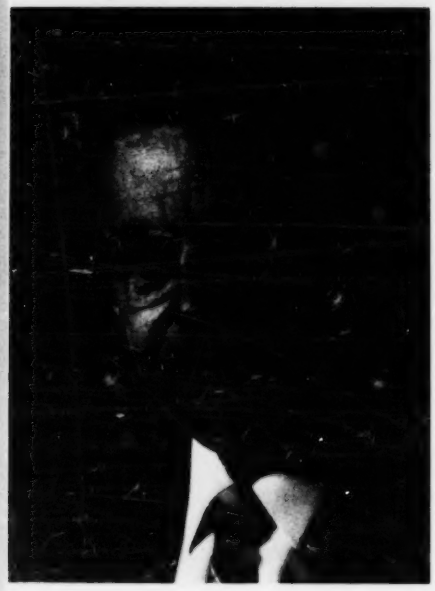
ELECTRICITY

ONTARIO'S FUTURE ELECTRICITY DEMAND

Ontario
Ministry of Energy
Honourable Vincent G. Kerrio
Minister

ENERGY 2000

ELECTRICITY



Ontario's Future Electricity Demand

Minister's Foreword

This paper has been prepared to provide information and stimulate discussion about future electricity demand in Ontario – as part of the Ministry of Energy's planning process to address the Province's electricity future.

As with other energy forms, our use of electricity has changed considerably since the early 1970s. Technology, lifestyles, economic conditions and world energy markets have all influenced the level and pattern of electricity consumption over the past decade and a half.

It takes many years to put in place the necessary facilities for generating and distributing electrical power. Ontario Hydro is currently examining a broad range of demand and supply options for meeting the province's future electricity needs. The Ministry of Energy will be reviewing Hydro's proposals in the context of the Province's energy policy objectives.

In order to carry out such a review it is necessary to have a long-range view of Ontario's electricity demand. The Ministry has already released a paper, "An Energy Efficient Ontario", which set out goals and objectives for energy efficiency throughout the economy.

How will our electricity needs change in the future? This paper assesses the longer-term prospects within the context of all our energy requirements. It also examines how developments in the economy, in oil and natural gas markets, and in technology are likely to affect our use of electrical energy.

Vincent G. Kerrio

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July 1987

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Executive Summary

Ontario's need for electricity is expected to grow steadily through to the end of the century, but more slowly than the economy. This represents a sharp break from trends established in earlier decades. Since 1982 electricity consumption has actually been increasing at four-fifths of the economy's growth rate. This fundamental shift reflects continuing structural changes in the economy and in the way energy is used.

Three factors account for the slower growth that is foreseen for electricity demand. First, the service sector may account for two-thirds of the growth in the economy between now and the year 2000. This sector uses only half as much electricity per dollar of output as the industrial sector. Second, energy-efficient technologies are being increasingly adopted throughout the economy – in space heating, in industrial processes and in the operation of household appliances. This will be a major restraining force in the demand for all forms of energy including electricity. Third, the fall in oil and natural gas prices since 1985 has made electricity less competitive and the effect will be slower expansion of electricity markets.

Key Findings

- Under the most likely assumptions, Ontario's electricity requirements could grow at a rate of 2.3 per cent a year between 1985 and 2000. This rate would be three-quarters of the growth in the economy's output of goods and services.
- Despite this relatively slow growth, the province will use about 40 per cent more electricity by the turn of the century.
- Residential electricity use would grow only slowly – just over one per cent a year. The main reasons are slower population growth, lower heating requirements for new homes, the replacement of existing appliances with more efficient ones and the reduced price competitiveness of electricity as a space heating fuel.
- Electricity consumption in commercial and institutional buildings would grow at a rate of 2.6 per cent per year as efficiency improvements in lighting and air conditioning more than offset the greater use of computers and electrical equipment.
- Industrial electricity use would increase at annual rates just under 3.0 per cent, only slightly faster than industrial output. Improvements in efficiency partly offset the greater reliance on electricity in new processes.
- Different scenarios could produce a range of demand growth paths. For example, with strong electricity conservation actions by government and utilities, growth could be as low as 1.4 per cent a year. Conversely, if the

economy became more electricity intensive over this period electricity growth could reach 3.4 per cent annually.

- For a range of energy price and economic outlooks, electricity demand growth could average between 2.0 and 2.7 per cent per annum to the turn of the century. In the next few years a relatively buoyant economy could push the growth rates above the long - term average.

Introduction

Ontario's energy bill in 1986 amounted to $12.5 billion, 6.5 per cent of the total value of all goods and services produced in the province. Energy is vital to every sector of the economy. It is used to heat and light houses and other buildings, move people and goods, operate machinery, raise steam and heat for industrial processes and make petrochemicals. The amount of energy used in the province and the prices paid for fuels will continue to affect the competitiveness of the Ontario economy and the quality of life of Ontario residents.

The Ontario Ministry of Energy regularly prepares long-range projections of energy prices and energy demand for Ontario as an aid to planning by government, utilities, industry and consumers. The last such projections were released by the Ministry in September 1985 as part of the Energy 2000 series of publications.

Since then, there have been significant changes in the world, Canadian, and Ontario energy scenes.

- International crude oil prices have fallen from just over $30 U.S. a barrel in November 1985 to as low as $10 in mid-1986. For 1986 as a whole, prices averaged $15, although they have moved up in 1987 in response to production restraints by members of the Organization of Petroleum Exporting Countries. Canadian oil prices, deregulated in mid-1985, have declined in a similar manner.
- Natural gas markets in the United States have been deregulated and competition has forced prices down. Since the fall of 1985, Canada has been opening up its markets and prices have come under downward pressure.
- The Ontario economy has been expanding rapidly, partly because of the drop in energy prices. The economic growth outlook is much improved from two years ago, particularly in the near term.

Future electricity prices and demand will be affected by on-going changes in the economy and energy markets.

- While oil and natural gas prices have fallen dramatically due to market forces, committed additions to generating capacity will keep upward pressure on electricity prices. Consequently, the relative price attractiveness of electricity has declined, at least in the near term.
- Electricity export sales have fallen considerably since 1984 and Ontario is now a net importer of electricity. This will mean higher rates because the profits from export sales have helped to keep rates low for Ontario customers in the past.
- Inflation rates are now expected to be lower than previously forecast. Electricity production is very capital intensive and depreciation charges

make up a large proportion of Ontario Hydro costs. During times of high inflation these charges decline significantly in real terms, offsetting increases in operations and fuelling costs. If lower inflation expectations are realized, Hydro's depreciation charges will not decline as quickly in real terms as had previously been anticipated.

- The higher expectations for economic growth in Ontario suggest that growth in electricity demand will be higher than previously forecast. This is partly offset, however, by the worsening competitive position of electricity relative to fossil fuels and the introduction of new technologies which use electricity more efficiently.

A long-range outlook for energy demand, including electricity and other energy forms, is a necessary part of the process of planning the province's energy system. The Ministry has developed a reference outlook that reflects a reasonably healthy future for the Ontario economy, with world oil prices in the range of $20 U.S. (in real 1986 $) in the 1990s.

Four alternative outlooks are also presented to examine the impact of different assumptions. Two of these alternatives examine the sensitivity of future electricity demand to variations in the intensity of electricity use. In one, Ontario Hydro and the Ontario government are assumed to undertake aggressive programs for conserving electricity (High Conservation). In the other, the economy is assumed to become more electricity intensive as a result of new technology adoption and lack of energy conservation (High Electricity Demand).

The other two alternatives reflect the major uncertainties about world oil prices and their impact on the Ontario economy. One possibility is that economic growth would be higher if low oil prices were sustained. On the other hand, economic growth could be slower if oil prices return to around $25 U.S. – close to 1985 levels – by the early 1990s. (Throughout this paper oil prices are expressed in 1986 US $ per barrel.)

The body of this report describes the outlook for Ontario electricity demand to the year 2000. The Appendix summarizes the prospects for other fuels and energy demand in total.

Growth in Electricity Demand Since 1970

Between 1982 and 1986, Ontario's electricity consumption increased by 4.6 per cent a year, a significantly higher growth than in the previous decade. This high growth was driven by:

- very strong economic growth averaging 5.7 per cent annually;
- strong growth in those industries which are large users of electricity, such as mining, pulp and paper, smelting and refining, iron and steel, and chemicals; these industries rebounded strongly from low output levels during the 1981-82 recession;
- high natural gas and oil prices during most of the period, which encouraged increased electricity use in heating buildings and in many industrial applications;
- government off-oil programs, including the Canada Oil Substitution Program, under which Ontarians converted over 80,000 homes to electric space heating between 1980 and 1985; and
- strong investment in new housing and commercial buildings.

Ontario's Electricity Use, 1982-1986

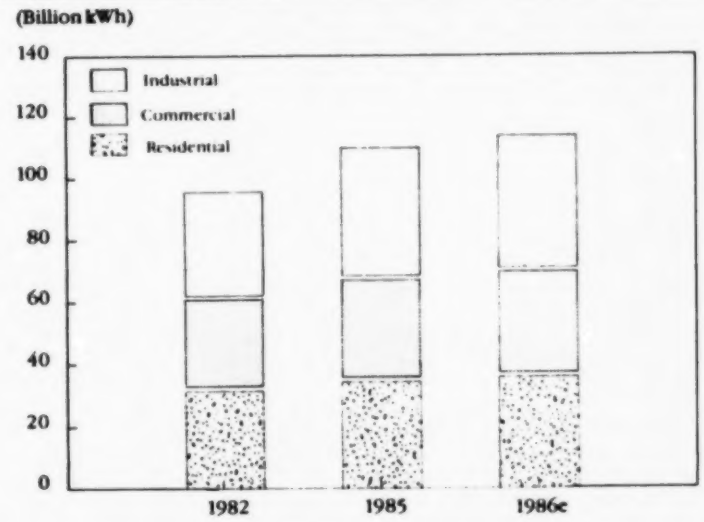


Table 1

Ontario's Electricity Use, 1982-1986

(Annual Percentage Change)

Sector	Electricity Consumption Growth	Economic Indicator	Growth
Residential	5.6	Housing Stock	1.7
Commercial	4.5	Services Output	5.4
Industrial	6.1	Manufacturing and Mining Output	6.4
All Sectors	4.6	Gross Provincial Product	5.7

Source: Statistics Canada, Conference Board of Canada and Ontario Ministry of Energy

Table 2

Electricity Growth by Industry, 1982-1986

(Cumulative Percentage Change)

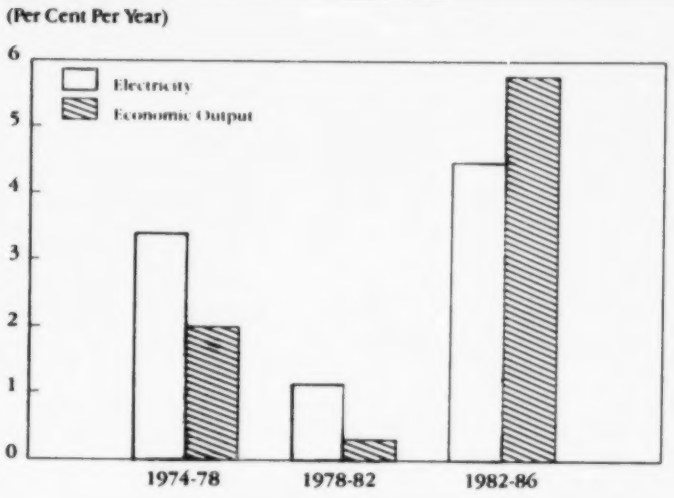
Industry	Electricity Demand	Output
Pulp and Paper	12	25
Iron and Steel	20	16
Mining and Metals	44	65
Chemicals	35	29
Other Manufacturing	11	28
Total Mining and Manufacturing	27	28

Source: Statistics Canada, Conference Board of Canada and Ontario Ministry of Energy

Despite these favourable factors, electricity consumption growth did not keep pace with the economy. Electricity use grew at four-fifths of the economy's growth rate in the period from 1982 to 1986. This experience represents a major break from earlier trends.

Between 1970 and 1982, by comparison, electricity use in the province grew 3.5 per cent annually; this growth rate was one and a half times as fast as the economy's. The residential sector experienced the fastest growth with demand increasing 5 to 6 per cent per year. In the commercial and industrial sectors electricity use grew at annual rates of 4.5 and 1.5 per cent, respectively.

Electricity Use and Economic Growth, Ontario, 1974-1986



A Reference Case with $20 Oil

The Economic Outlook

The long-term reference outlook foresees continued strength for the Ontario economy. Over the 1985-2000 period, economic growth could average 3.2 per cent a year, with particularly healthy growth in the medium term to 1990. Ontario's strong competitive position in export markets, skilled workforce, and continued investment in new productive capital should provide the basis for continued growth in output and living standards. Inflation is expected to remain largely under control, averaging slightly below 4 per cent. The unemployment rate will decline from current levels, averaging just above 6 per cent over the outlook period.

Oil prices are projected to remain well below the levels of the early 1980s. After averaging $15-16 U.S. (in real 1986 $) for the rest of the decade, prices are forecast to rise to the $19-20 range in the 1990s reflecting rising demand and reduced supply from areas such as the North Sea and the United States. Wholesale natural gas prices are expected to fall relative to oil prices from 1986 on, with the price ratio dropping to 80 per cent by the late 1990s.

In the medium term, the large drop in oil and natural gas prices which occurred in 1986 is expected to contribute to very strong growth. Moderate inflation and lower real interest rates will sustain consumer spending and business and housing investment. Manufactured exports should respond to stronger growth in the U.S. economy and the fall in the Canadian dollar against Japanese and European currencies. Over the 1985-90 period economic growth could average 4.0 per cent per annum.

During the 1990s, economic growth is expected to be more moderate. This slowing would be partly in response to rising real oil prices in the early 1990s, but due primarily to declining labour force growth. The aging of Ontario's population could cause labour force growth to fall below 1.5 per cent a year. Combined with moderate improvements in productivity, annual economic growth in the 1990s would average 2.8 per cent.

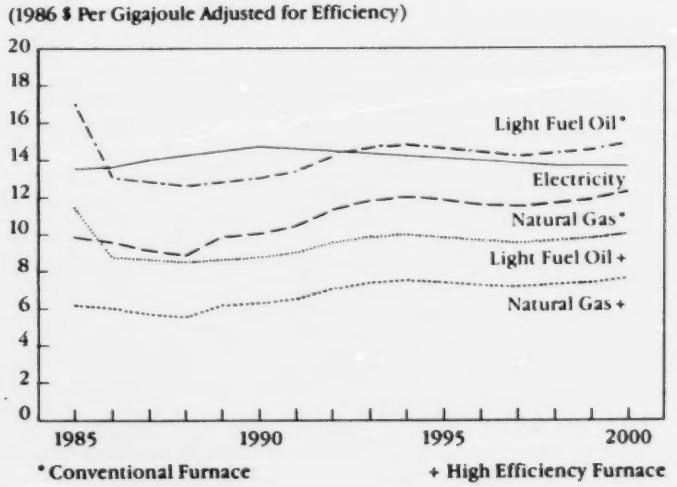
Manufacturing is expected to be strong in the medium term, with output increasing at 3.8 per cent a year as the drop in energy prices acts as a stimulant to trade. Growth could slow significantly in the 1990s, for the reasons noted above, with the result that over the full forecast period manufacturing output growth could average 2.8 per cent annually.

Service sector activity is assumed to expand more strongly than manufacturing throughout the period, averaging 3.4 per cent per annum. Increased information needs, an aging population and rising demand for recreational, household and business services will all contribute to expanding service activity.

Electricity prices are projected to continue their recent trend of increasing one to two percentage points above the rate of inflation in the next few years. After 1990, price increases could be below the rate of inflation as fewer new plants are brought into service and fixed capital charges, which are a major component of electricity costs, decline in real terms. This decline is likely to be slow as inflation is expected to be fairly low and stable. By the year 2000 electricity prices adjusted for inflation could be slightly below 1987 levels.

Residential Energy Prices

Reference Case



Note: Sixty per cent efficiency assumed for Natural Gas and Light Fuel Oil conventional furnaces. High efficiency natural gas and oil furnaces are assumed to be 96 and 90 per cent efficient, respectively. Propane prices are currently about $19/GJ (1986 $) adjusted for efficiency and will likely track fuel oil over the period.

Growth in Electricity Demand, 1985-2000

Over the 1985 to 2000 period, Ontario's electricity consumption could increase at an average annual rate of 2.3 per cent. This represents a significant decline from the rates experienced in the last four years. Lower growth is likely because the economy is expected to expand more slowly and because relative price and structural changes will tend to reduce electricity demand.

The very high economic growth rates in Ontario of the last four years are not sustainable over the long run. The healthy economic growth of 3.2 per

cent per year projected for the next 15 years is just over half that experienced between 1982 and 1986.

The changing age structure of the population will have substantial impacts on the Ontario economy in the 1990s. Labour force growth and household formation rates will decline significantly from earlier levels. These trends will reduce the economic growth potential and lower the demand for new housing in the 1990s.

The industrial sector – which uses almost twice as much electricity per dollar of output as the service sector – is expected to grow more slowly than the service sector in the 1990s. The shift from hard goods to services is an on-going structural phenomenon in mature, developed economies.

Electricity will likely be much less competitive with natural gas and oil in energy markets, particularly for space, water and process heating. Although natural gas and oil prices could begin to move up in the early 1990s, electricity might not return to the competitive position it held in the early 1980s. New technologies that improve the efficiency of electricity use are being more widely adopted by industry, households and commercial building owners.

Offsetting these factors, new plant and equipment will tend to be more reliant on electricity than existing equipment. Electrotechnologies might also become more important in certain industrial processes, and electrical equipment such as computers would be more extensively used in commercial and institutional buildings.

Ontario's Electricity Use in Relation to Economic Activity
Reference Case

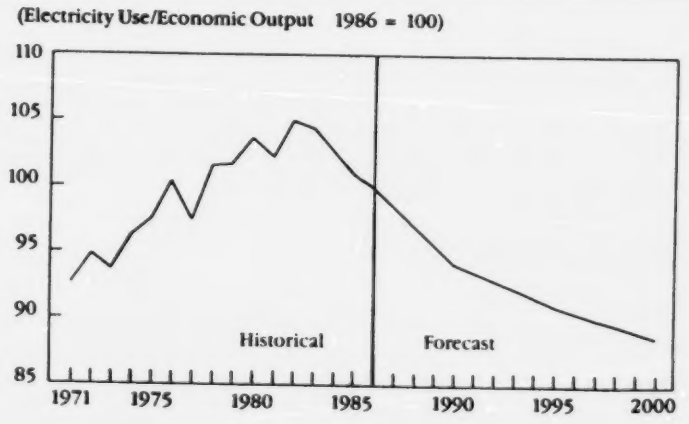


Table 3

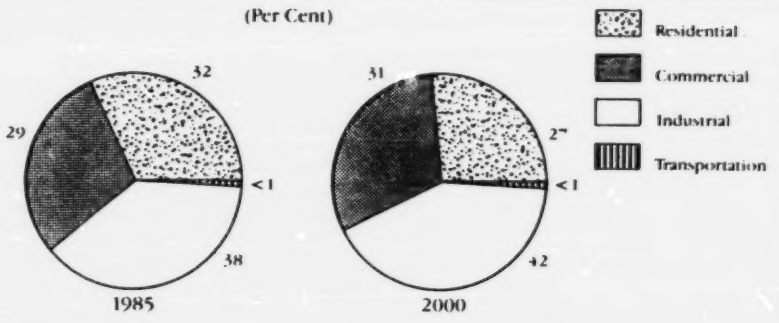
Ontario's Electricity Use, 1985-2000
Reference Case

	(Annual Percentage Change)		
Sector	Electricity Consumption Growth	Economic Indicator	Growth
Residential	1.1	Housing Stock	1.4
Commercial	2.6	Services Output	3.4
Industrial	2.9	Manufacturing and Mining Output	2.8
All Sectors	2.3	Gross Provincial Product	3.2

Electricity Demand by Sector

The strongest demand for electricity is expected to be in the industrial or goods-producing sector, which accounts for 38 per cent of Ontario's electricity use today. Commercial sector demand associated with service activities will also grow faster than the average. Residential electricity demand, however, is likely to grow much more slowly than in the past. The following sections explain why this pattern of growth is expected.

Electricity Shares by Sector, 1985 and 2000
Reference Case



Industrial

Strong growth in some large electricity-intensive industries, high levels of investment in new machinery, and the increased use of electrotechnologies such as robots, will tend to push up the overall intensity of electricity use. However, these factors will be mostly offset by the increased efficiency of new machinery, particularly electric motors and drives, and significant competition from other fuels, particularly natural gas in process heating uses.

Industrial electricity consumption is dominated by the manufacturing and mining industries, together with smaller amounts used in agriculture, forestry and construction. Over the full 1985-2000 period, electricity consumption by industry could grow at an average annual rate of 2.9 per cent, only slightly above the forecast growth of sectoral output.

Large Electricity Users

Four industries – pulp and paper, iron and steel, chemicals, and mining and non-ferrous metals – account for over 60 per cent of industrial electricity use. Accordingly, their strength will have considerable influence on overall electricity use by industry.

- The **pulp and paper industry** currently consumes almost one-fifth of industrial electricity. Over the forecast period, annual growth in electricity use could exceed growth in output as most newsprint capacity in Ontario

Table 4

Electricity Use by Industry, 1985 and 2000

Reference Case

Industry	Billion kWh 1985	Billion kWh 2000	MW Equivalent[1] 2000
Pulp and Paper	8	13	2,000
Iron and Steel	5	11	1,700
Chemicals	6	8	1,200
Mining and Metals	7	8	1,200
Other Manufacturing	16	26	4,000
Total Mining and Manufacturing	42	66	10,100

[1] Power requirement in megawatts (MW) assumes an average industrial load factor of 75 per cent.

Explanation of Terms

One kilowatt-hour (kWh or kW.h) is the most common measure of electrical energy. A 100 Watt light bulb operated for 10 hours would use 1000 Watt-hours or one kWh of electricity. One thousand kWh is just above the average monthly consumption of an Ontario household.

One million kWh is roughly the amount of electricity used in one year by one hundred houses. One billion kWh is equal to the amount of electricity used in Ontario in three days. Each of the four Darlington nuclear units will be capable of generating 35 billion kWh of electricity in a year.

One kilowatt (kW) is a common measure of electric power. Power is the rate at which energy is demanded. Peak demand is the highest rate at which electricity is demanded over a given period. This is usually measured as the average power demand over the one hour period in which demand is the highest. The annual peak is the highest rate at which electricity is demanded in a year. One thousand kilowatts or one megawatt (MW) is equal to the peak demand of one hundred electrically heated homes on the coldest day of the year.

One unit at the Darlington nuclear station has a capacity of 881 MW. Peak demand for electricity in Ontario on the coldest day of the year is between 20,000 and 21,000 MW.

Load factor refers to the ratio of average electricity demand to peak electricity demand. Annual load factors for electric utility systems will vary depending on the amount of the load that is temperature sensitive (space heating and air conditioning) and the size and nature of the industrial load (large industries operating on three shifts have high load factors). Ontario Hydro, because of its large, diverse customer base, has one of the highest annual load factors (around 67 per cent) among North American utilities.

is converted to thermomechanical pulping (TMP) processes for quality and environmental reasons. TMP consumes more electricity per tonne of newsprint than the conventional groundwood/sulphite process but produces higher quality newsprint with a much lower environmental impact.

- The **iron and steel industry** uses about one-eighth of the electricity consumed by Ontario industry. Most new capacity will likely be electric arc furnaces. The rest of steel production is also becoming more reliant on electricity. Accordingly, electricity use could grow significantly faster than output.
- The **mining and metals industries** account for just over 15 per cent of industrial electricity use. Electricity consumption would likely increase more slowly than output growth of about 2.0 per cent per annum because of efficiency gains. Growth in output is expected to be restrained by severe international competition.
- The **chemicals industry** accounts for almost 15 per cent of the electricity used by industry. Both output and electricity use may grow at an annual rate of 3.4 per cent.

The impact of these large electricity-intensive industries on total electricity requirements is illustrated in Table 4. By the year 2000, requirements by these four industries will have grown to 40 billion kilowatt-hours (kWh), an increase of 54 per cent.

Other manufacturing industries consume almost 40 per cent of industrial electricity, although they account for a much higher proportion of industrial

Electricity and Output Growth in Major Industries, 1985-2000

Reference Case

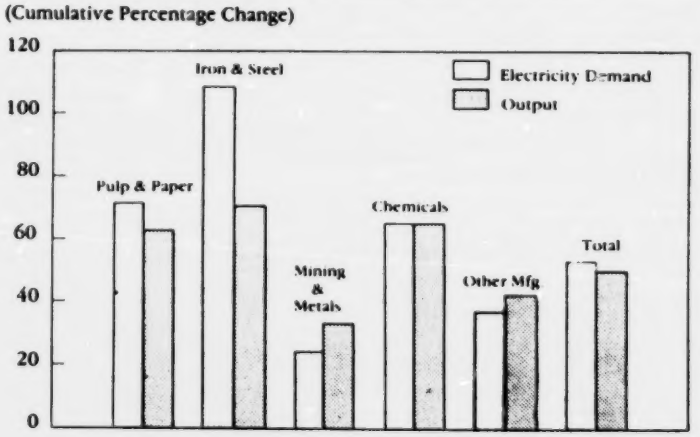


Table 5

Electricity and Output Growth by Industry, 1985-2000
Reference Case

(Annual Percentage Change)

Industry	Electricity Demand	Output
Pulp and Paper	3.7	3.3
Iron and Steel	5.0	3.5
Mining and Metals	1.5	2.0
Chemicals	3.4	3.4
Other Manufacturing	2.2	2.4
Total Mining and Manufacturing	2.9	2.8

output. As a result of improvements in electrical efficiency, for example in electric motors and drives, electricity use could grow more slowly than output.

Investment

Industrial investment is expected to be relatively strong over the next five years as interest rates have declined and are likely to remain fairly stable. As well, capacity utilization is high after four years of economic recovery. Investment in machinery and equipment and construction activity could each increase at annual rates of 6 per cent or more over the next 5 years. **Much of this new investment will be in plant and processes using more electricity** for process control, productivity and quality improvement reasons.

New and retrofit plants will make greater use of electricity to power computers and precision controlled machinery. Certain processes which could be adopted to improve quality, such as thermomechanical pulping, use more electricity than the processes being replaced.

New Technologies

The introduction of electrotechnologies will allow manufacturers to achieve greater process control and precision, increase output and produce higher valued products.

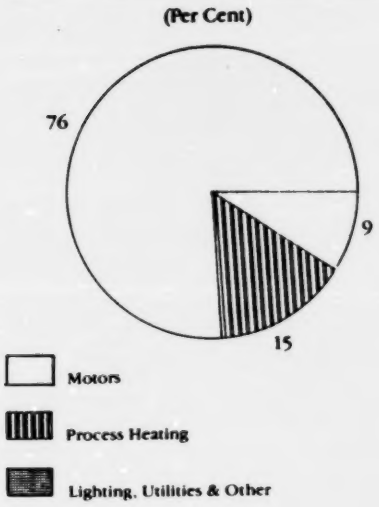
Machinery and manufacturing industries will increasingly adopt robotics and flexible manufacturing technology following the lead of countries such as Japan. General Motors of Canada, for example, has plans to install up to 1,000 robots over the next five years. Each robot could consume more than 200,000 kWh of electricity annually. Overall, new manufacturing processes in automobile plants could increase electricity consumption per vehicle produced by as much as one-third. Ontario industry's total electricity requirements for robotics and flexible manufacturing processes could amount to one billion kWh a year by the end of the forecast period.

Other electrotechnologies which could have a large impact on industrial electricity use include:

- plasma arc systems (to replace blast furnaces in steel making, for direct reduction of metals, and in hazardous waste disposal);
- high temperature heat pumps for waste heat recovery;
- electrical drying processes (wide variety of applications in the paper, wood, textile, food and non-metallic minerals industries); and
- lasers in cutting applications.

These are not expected to be extensively adopted before the end of the century in this outlook.

Industrial Electricity Use, 1986

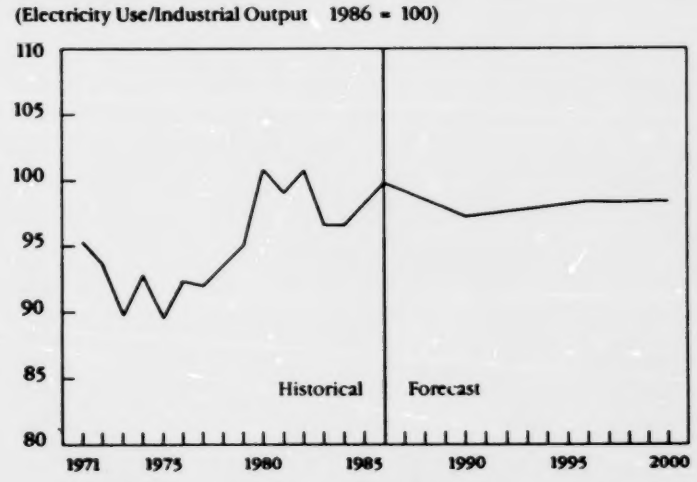


Electric Motors

Electric motors currently account for three-quarters of the electricity used by Ontario's industries. While savings can be achieved by installing high-efficiency motors when existing motors need to be replaced, much larger efficiency gains are possible through changes in the way they are operated. By carefully sizing motors to match load, using adjustable speed drives, and operating motors more efficiently, significant electricity savings are possible. For certain applications savings of up to 25 per cent can be achieved.

It is estimated that the adoption of these measures will reduce electricity use per motor by 5 per cent between 1985 and 1990 and by a further 5 per cent in the 1990s.

Electricity Use Relative to Industrial Output
Reference Case

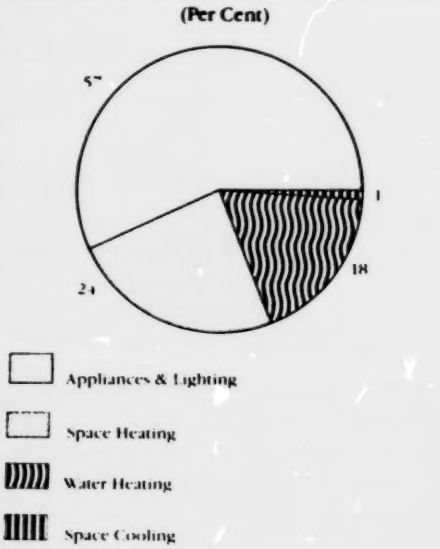


Price Competitiveness

Industrial natural gas users have negotiated price reductions of as much as 25 per cent since the end of 1985. Heavy fuel oil prices have dropped dramatically with the fall in crude oil prices, which began in late 1985. In contrast, electricity prices have risen steadily and further increases are expected in each of the next few years.

As a result of these relative price changes, electricity has become less attractive as a fuel in process heating applications, particularly for raising steam in boilers. New, more efficient technologies for using natural gas in high temperature applications, such as metal melting and forming, will further limit the use of electricity in process heating.

Residential Electricity Use, 1986



Industrial Electricity Intensity

Electricity intensity – the amount used per unit of output – will not continue to increase as in the 1970s. Intensity will stabilize at levels somewhat below the peak levels reached in 1980.

Residential

Electricity is used by households for appliances, lighting, space and water heating, and space cooling. Total electricity use by households is forecast to increase by only 1.1 per cent annually over the forecast period. This is much lower than recent growth rates of between 3 and 6 per cent a year in the 1970s and early 1980s, when electricity was greatly increasing its penetration of home heating markets.

Growth in residential electricity demand will be driven mainly by:

- growth in the housing stock;
- the price competitiveness of electricity in space and water heating applications; and
- the development and takeup of more efficient appliances.

Housing Stock

Additions to the housing stock, over the period, will affect the growth in residential electricity demand in several ways. First, new housing increases the demand for energy through heating requirements, lighting, appliances and lifestyle choices of the occupants. New housing and appliances are expected to be significantly more efficient than the existing stock. Some new houses, such as the R-2000 homes, far exceed standard building code requirements for insulation, use double or triple-glazed windows, and are designed to prevent warm air leakage.

Moreover, housing starts are expected to decline significantly from current high levels in response to slower population growth and household formation. Over the projection period the total stock of houses and apartments could grow by an average of 1.4 per cent per annum, or about 55,000 units annually. Growth will be above this average in the medium term and below it in the 1990s as population growth slows.

The existing housing stock will continue to be upgraded through the addition of insulating materials, thermal windows and weatherstripping.

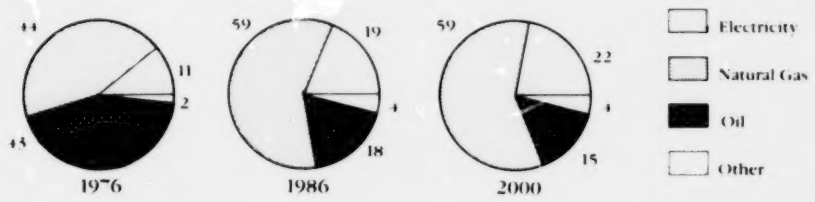
These factors tend to curb the growth of all energy types including electricity. As discussed in the next subsection, electricity demand growth is likely to be significantly restrained because of price competition among fuel types for space and water heating.

Space Heating

Over the past five years, electricity has faced strong competition from natural gas in the space heating market. In Ontario, conversions to natural gas from oil made under the Canada Oil Substitution Program outnumbered conversions to electricity by three to one. The termination of this program and the recent decline in oil prices have ended much of the incentive for homeowners to convert from oil to electricity. In the new housing market, depending on location and type of house, natural gas currently claims a 60-90 per cent market share. In the new apartment market, gas and electricity appear to hold roughly equal shares.

Residential Space Heat Fuel Shares
Reference Case

(Per Cent of Households)



Electricity's competitive position in space heating has worsened significantly with the decline in oil and natural gas prices. Natural gas is currently between 35 and 60 per cent cheaper than electricity as a fuel depending on furnace efficiency. Oil, at least in the near term, is once again a lower cost fuel for space heating. As a result, electricity will not be able to increase its share of the space heating market significantly, particularly in the short run. As fossil fuel prices firm, electricity could become a more attractive fuel for space heating during the 1990s.

Over the forecast period electricity is projected to heat one-third of new homes and two-thirds of new apartments, the latter because of the growing acceptance of heat pumps in apartment buildings. By the end of the century, electricity could account for 22 per cent of the space heating market compared to 18 per cent today.

However, conservation investments have also had an impact on electricity consumption for space heating. Since 1981, improvements in household insulation and airtightness have reduced space heating requirements in an average electrically heated home by three per cent, and this trend is expected to continue.

Table 6

Electricity Requirements per Appliance
Reference Case

(1986 = 100)

	1978	1986	2000
Refrigerators	107	100	74
Freezers	110	100	71
Clothes Dryers	104	100	91
Washing Machines	100	100	98
Stoves	100	100	98

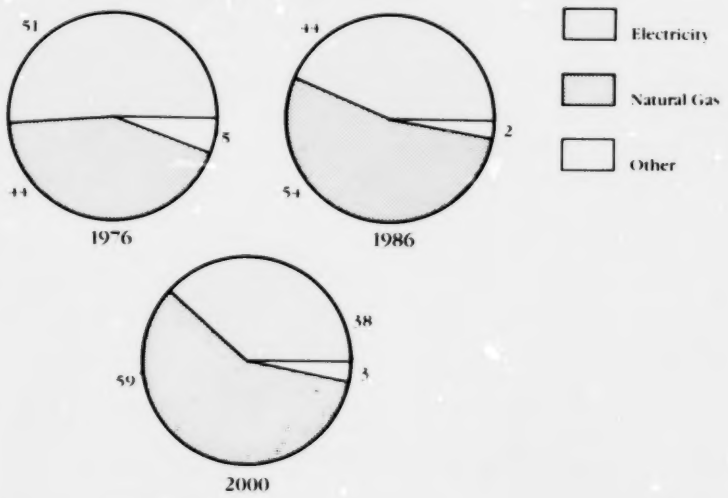
Water Heating

Since the mid-1970s electricity has steadily lost market share to natural gas for water heating. Electricity's share has declined from 52 to 45 per cent of households since 1980. Natural gas has been more attractive on a cost basis and its market share has risen from 44 to 52 per cent. It is assumed that natural gas will continue to capture market share from electricity.

Electricity has been and will continue to be, the principal water heating fuel in those homes with electric or oil space heating.

Residential Water Heat Fuel Shares
Reference Case

(Per Cent of Households)



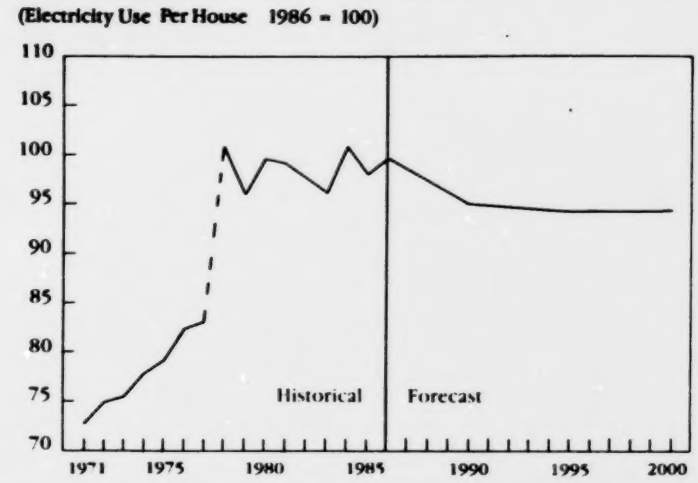
Appliances and Lighting

Appliances and lighting account for 50 to 60 per cent of household electricity use. The major users are refrigerators, freezers, stoves, washing machines, clothes dryers, dishwashers and colour TVs.

A recent study carried out for the federal government estimated that appliance efficiencies have improved significantly over the last few years. For example, the average efficiency of freezers sold in Canada improved by 29 per cent between 1978 and 1984. For new refrigerators, the improvement was 23 per cent. Further efficiency improvements are expected.

Given the natural equipment replacement cycle, about two-thirds of the major appliances in use today will be replaced by more efficient models by the year 2000. By then, the combined impact of these two factors could lead to an overall appliance efficiency gain of 18 per cent.

Residential Electricity Use Per Household
Reference Case



Note: Change from 1977 to 1978 resulted from modifications to Statistics Canada methodology. Before 1978 apartments were included in the commercial sector.

Nevertheless, the market for major new appliances will continue to expand with rising personal incomes, growth in new housing and appliance replacement demand. New products such as home computers are also expanding market share. Consequently, electricity use for appliances will grow, albeit at a moderate rate of 1.5 per cent a year.

Commercial and Institutional Buildings

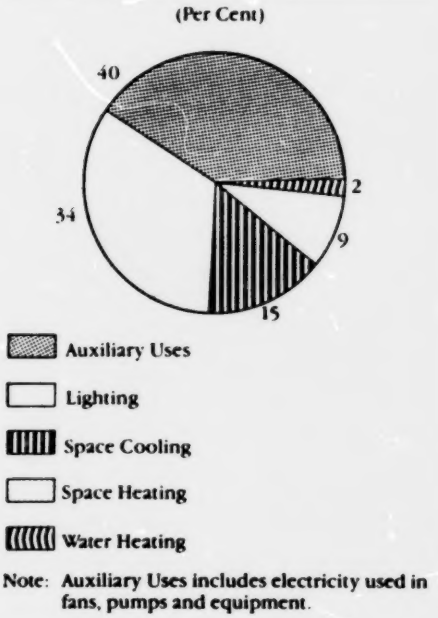
Electricity is used in commercial and institutional buildings for equipment, lighting, cooling and some space and water heating. Total use in this sector could expand at an average annual rate of 2.6 per cent over the 1985 to 2000 period. Growth in electricity consumption will be influenced primarily by:

- growth in service sector activity and floorspace;
- the price competitiveness of electricity; and
- efficiency improvements.

Service Sector Activity

Total service sector economic activity could grow at an average rate of 3.4 per cent a year over the forecast period. The growth of building stock such as offices, stores and hotels, will contribute to growing demand for electricity. Activity will grow faster in the commercial sector but more slowly in institutional sectors such as schools and government offices, largely reflecting the trends in population growth.

Commercial Electricity Use, 1986



Note: Auxiliary Uses includes electricity used in fans, pumps and equipment.

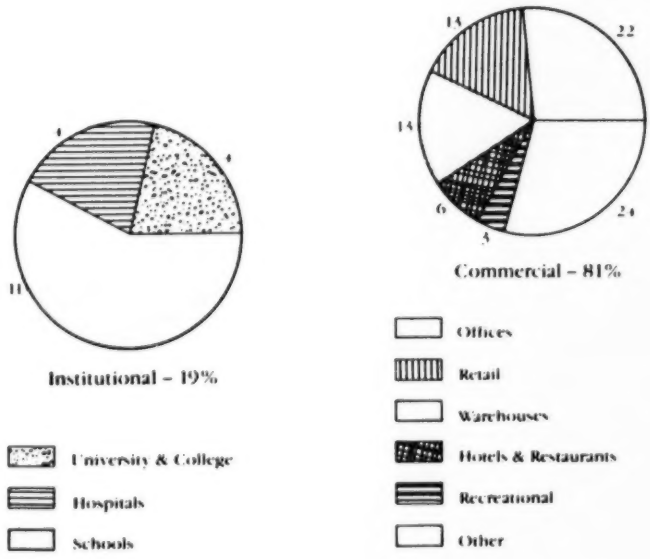
Floorspace

Over the 1980 to 1985 period, commercial sector floorspace (offices, retail space, warehouses, hotels and restaurants) expanded at about five-sixths of the growth in service sector economic activity. This is down from the one-to-one relationship that prevailed in earlier periods reflecting increases in output from a given building space. For the forecast period it is expected that floorspace will increase at 2.7 per cent per year on average, about 85 per cent of the rate of growth in service sector output.

Total floorspace in this sector was estimated to be over 170 million square metres in 1985. Commercial structures accounted for 81 per cent of the building stock; institutional buildings made up the remainder.

Commercial and Institutional Floorspace by Building Type, 1985

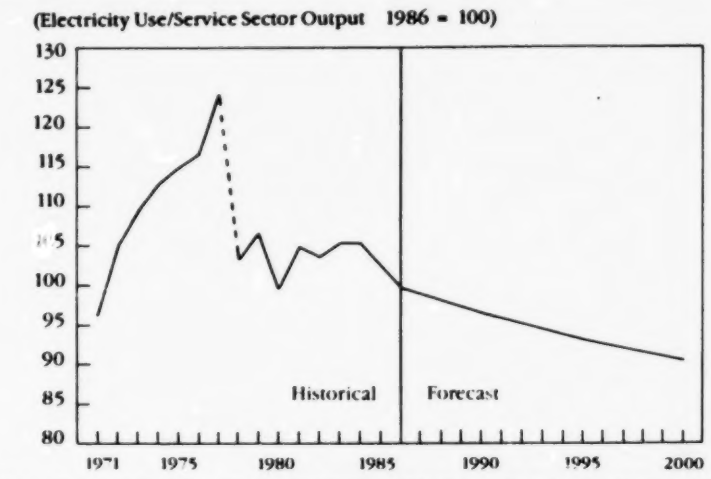
(Per Cent of Floorspace)



The growth in building stock will give rise to increased electricity use for lighting, heating, and equipment such as fans, pumps and elevators. In addition, commercial activity increasingly depends on the use of electrical and electronic equipment such as computers and telecommunications equipment. However, these applications are not heavy users of electricity.

The recent decline in price competitiveness makes it less likely that electricity will significantly increase its current small share of the space heating market in this sector.

Commercial Electricity Use Relative to Service Sector Activity
Reference Case



Note: Change from 1977 to 1978 resulted from modifications to Statistics Canada methodology. Since 1978 apartments have been included in the residential sector; previously they were included in the commercial sector.

Efficiency Improvements

Lighting accounts for over one-third of electricity used by this sector. The technical potential for efficiency gains in lighting is enormous. It is assumed in this outlook that lighting electricity use per unit of floorspace will be reduced by around 15 per cent on average between 1985 and 2000, with even greater reductions in some building sectors. This would amount to annual savings in electricity use of 1.4 billion kWh or about 250 MW of peak reduction by the end of the period. Large efficiency improvements are also possible in auxiliary uses such as pumps, fans, motors, office equipment and other applications. The average gain in efficiency for these uses could be 7.0 per cent over the period. By the year 2000 this would amount to annual electricity use savings of 2.1 billion kWh or 350 to 400 MW of peak reduction.

In conclusion, the commercial sector will grow more strongly than the economy as a whole. Nevertheless, improved efficiency of electricity use will hold growth in electricity demand to increases averaging 2.6 per cent a year.

Transportation

Electricity is used in urban public transit to power subways, streetcars and trolley cars and currently accounts for less than one-quarter of one per cent

of total electricity use. Any increase in electricity use resulting from the proposed expansion of the Toronto subway system may be partly offset by the replacement of some trolleys with diesel buses. Other electricity transportation uses are not significant; there are currently only 46 electric vehicles registered in the province.

At this stage there do not appear to be any developments which would significantly increase electricity use for transportation before the year 2000, such as electrification of commuter and passenger rail lines. While the technology for electric vehicles continues to improve, it could be several years before commercialization becomes a reality.

The Sensitivity of Future Electricity Demand

Ontario's future electricity demand could vary from the growth path foreseen in the Reference Case for many reasons. The following analysis looks at four different scenarios which help to place bounds on the possible future demands.

High Conservation

There is a vast technical potential for more efficient electricity use. The achievement of this potential is constrained, however, by slow turnover of old equipment, consumers' preference for reducing up-front capital costs, and institutional factors.

This scenario looks at some of the areas where electricity is heavily used and the potential for improved efficiency is the greatest. It estimates the impact on total electricity use that would arise from specific achievable improvements in efficiency in each of these sectors. Most of these improvements rest on much greater adoption of known technology. However, to achieve these gains would require stronger utility and government leadership in the form of incentives and mandated standards, as well as greater focus on electricity efficiency by businesses and individual consumers. It is noteworthy that the United States has already legislated strong appliance efficiency standards.

In such a high-efficiency scenario with large-scale government and utility programs, electricity consumption growth could be as low as 1.4 per cent a year.

In the **industrial** sector, for example, programs designed to improve technical efficiency of motors and geared to the wider adoption of high-efficiency equipment could double efficiency gains estimated in the Reference Case.

- By 2000, annual electricity savings in the industrial sector might amount to 5 billion kWh or 700 to 800 MW of peak reduction compared to the Reference Case.

Residential electricity use could increase only slightly over the period. This assumes that R-2000 building standards would be achieved for new homes using electric space heating and that stringent efficiency standards would be adopted for new appliances. These appliance standards would result in a one-third savings in average appliance electricity use by the year 2000 over 1985 levels. Greater use of heat pumps, primarily in new apartment buildings, could be encouraged so that by the end of the period there would be over 300,000 heat pumps compared to 200,000 in the Reference Case.

Table 7

Comparison of Electricity Demand Outlooks

A. Demand Growth, 1985-2000 (Per Cent Per Annum)

Sector	High Conservation	Reference Case	High Electricity
Residential	0.1	1.1	2.6
Commercial	1.5	2.6	4.1
Industrial	2.4	2.9	3.4
All Sectors	1.4	2.3	3.4

B. Electricity Consumption (Billion kWh)

Sector	1985	High Conservation 2000	Reference Case 2000	High Electricity 2000
Residential	36	37	42	53
Commercial	33	41	49	60
Industrial	43	61	66	71
Total	112	139	157	184

- Overall, residential conservation standards and programs could reduce annual electricity requirements in 2000 by 6 billion kWh.

In the **commercial** sector a lighting replacement program for existing buildings and the adoption of more efficient lighting for new buildings is assumed. The resulting saving could be as much as 45 to 50 per cent per unit of floorspace. Also promotion of better equipment and design could reduce electricity use in space cooling by 35 to 40 per cent for new buildings and in auxiliary uses by 20 per cent.

- Overall, electricity requirements in commercial and institutional buildings could be reduced by 7 billion kWh by the year 2000.

The aggregate result of such a High Conservation scenario would see total electricity consumption 11 per cent below the Reference Case outlook by the year 2000.

High Electricity Demand

Electricity-using processes and applications could be adopted at a much faster rate than assumed in the Reference Case. Electricity could increase its penetration into many energy markets through greater investments in new, more electricity-intensive technologies. At the same time, efficiency improvements could be lower than envisaged in the Reference Case. Electricity's advantages such as cleanliness, temperature control, and enhanced product quality might be attractive enough to industry and consumers to overcome its relative price disadvantage. **In such a scenario, overall electricity consumption growth could be as high as 3.4 per cent annually.**

Certain **industrial** sectors might introduce processes which use large amounts of electricity. For example, nickel smelters might be converted to electric furnaces in order to meet environmental regulations. Similarly, plasma arc technology may replace conventional blast furnaces for a large share of iron and steel making capacity. This could occur if the costs of coking coal and coke oven replacement were too high. However, it would require significant improvements in plasma arc technology.

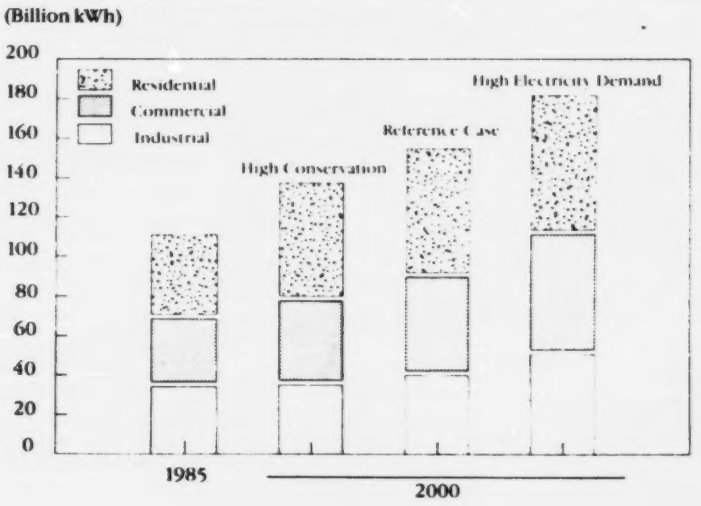
Residential electricity consumption could expand by up to 2.6 per cent a year, if consumer preference and lifestyle choices were to favour electricity use. The penetration of electricity in the space heating market would be much higher than anticipated in the Reference Case. By the year 2000, electricity would hold a 30 per cent share of the space heating market. Electricity use for air conditioning could also expand considerably.

Commercial sector electricity use could increase by as much as 4.1 per cent per year. In this case it is assumed that commercial floorspace grows in line with service sector output and that auxiliary electricity use per employee is

25 per cent higher than foreseen in the Reference Case. As a result, service sector activity becomes more electricity-intensive. In addition, a low takeup of high-efficiency light bulbs and motors, for example, would keep efficiency gains below levels envisaged in the Reference Case. Electricity's share of the space heating market could double to 20 per cent by the end of the period.

Overall, by the end of the century electricity use in the High Electricity scenario would be 15-20 per cent above the levels projected in the Reference Case.

Electricity Use, 1985 and 2000
Reference Case and Variations



Electricity Use Relative to Economic Growth
Reference Case and Variations

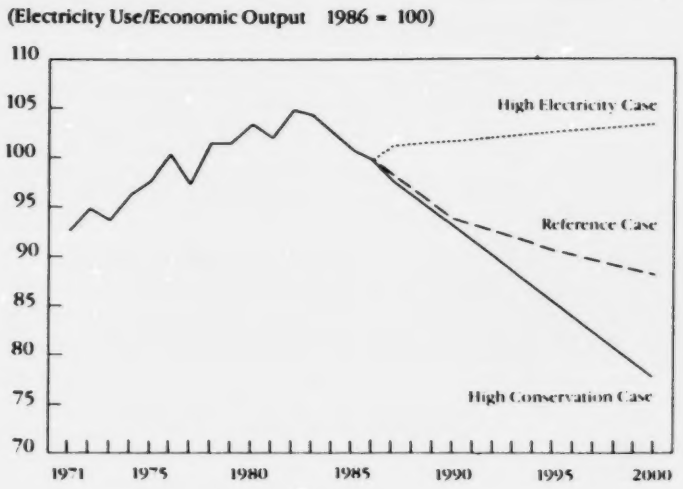


Table 8

Growth in Ontario's Electricity Use, 1985-2000
$25 Oil Scenario

(Annual Percentage Change)

Sector	Electricity Consumption Growth	Economic Indicator	Growth
Residential	0.9	Housing Stock	1.3
Commercial	2.4	Services Output	3.1
Industrial	2.4	Manufacturing and Mining Output	2.5
All Sectors	2.0	Gross Provincial Product	2.8

A $25 Oil Scenario

This scenario envisages a more rapid recovery in oil prices, reaching $20 (in real 1986 $) by 1990 and averaging around $25 by the late 1990s, not far from levels before the recent drop in prices. Ontario economic growth would be reduced by the depressing effect of higher oil prices on the world economy. Over the forecast period, economic growth could average 2.8 per cent annually, inflation might exceed 4.0 per cent and the unemployment rate could be just under 7 per cent.

Electricity consumption might grow by 2.0 per cent annually in response to slower economic growth. The manufacturing sector and especially the resource-based industries would experience particularly slow growth. As oil and natural gas prices begin to rise in the 1990s electricity would become increasingly competitive in heating applications. However, electricity would not regain the competitive position it enjoyed in the early 1980s until near the end of the forecast period.

In each sector, electricity demand growth would be lower than in the Reference Case as slower economic growth outweighs the effect of increased price competitiveness.

Industrial electricity use could increase at an average rate of 2.4 per cent per year over the forecast period, just below the growth rate in industrial output. A sluggish investment outlook and slower growth in resource-based industries would tend to restrain growth in electricity demand.

Table 9

Growth in Ontario's Electricity Use,1985-2000
$10 Oil Scenario

(Annual Percentage Change)

Sector	Electricity Consumption Growth	Economic Indicator	Growth
Residential	1.6	Housing Stock	1.5
Commercial	2.9	Services Output	4.0
Industrial	3.2	Manufacturing and Mining Output	3.2
All Sectors	2.7	Gross Provincial Product	3.6

Residential electricity consumption growth could average 0.9 per cent a year. Housing starts, the average size of homes, the proportion of single detached homes and appliance use would all be less than in the Reference Case because of lower levels of personal disposable income. Each of these factors would tend to reduce electricity consumption.

Commercial and institutional buildings' use of electricity could expand at an average annual rate of 2.4 per cent while service sector activity could increase at a 3.1 per cent rate. While service sector activity is lower than in the other cases, increasing oil and natural gas prices would improve the competitiveness of electricity for space and water heating applications and make heat pumps and energy-efficient buildings more attractive. **On balance electricity use would grow more slowly than in the Reference Case.**

A $10 Oil Scenario

This scenario assumes that oil prices fall further in 1987 and remain low through the rest of the century. It illustrates the gains to the developed industrial economies that low oil prices could provide, although there could be losses in energy-producing regions. It is acknowledged that this is not a likely scenario, and that sustained low oil prices could lead to financial instability for producing nations and intensify international debt problems.

Lower oil prices could give a large boost to Ontario's economy, especially in the early part of the period. The manufacturing sector would benefit the most from increased trade, lower energy costs and greater consumer purchasing power. Over the full 1985 to 2000 period, annual economic growth could be 3.6 per cent, inflation could average 3.5 per cent and the average unemployment rate could be less than 6.0 per cent.

Provincial electricity consumption could increase by 2.7 per cent per year on average, driven by higher economic growth particularly in the manufacturing sector. However, the persistence of very low oil and gas prices with electricity prices rising at about the rate of inflation, would reduce the attractiveness of electricity in space, water and process-heating applications where users have a choice of fuel.

Industrial electricity consumption would keep pace with growth in output, averaging about 3.2 per cent annually. Business investment would be quite healthy, resulting in the wider adoption of new electricity-using processes by industry.

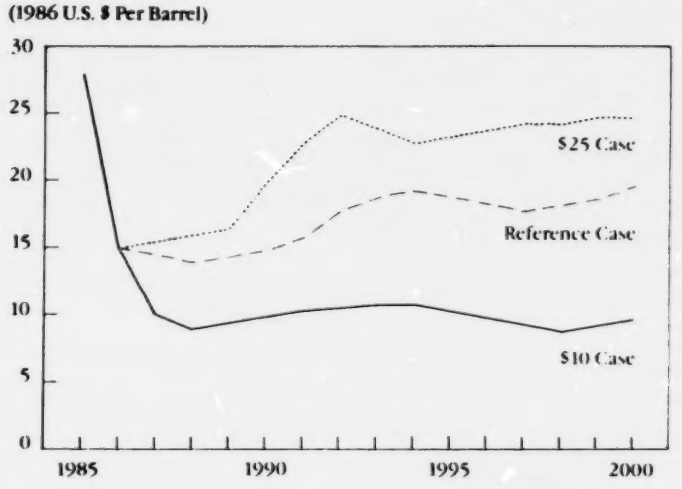
Residential electricity use could increase about 1.6 per cent a year on average. Higher levels of personal disposable income than in the Reference Case will raise housing and appliance demand.

In **commercial and institutional** buildings, electricity use could expand at an average annual rate of 2.9 per cent over the forecast period. Economic activity in the service sector could grow by 4.0 per cent per year

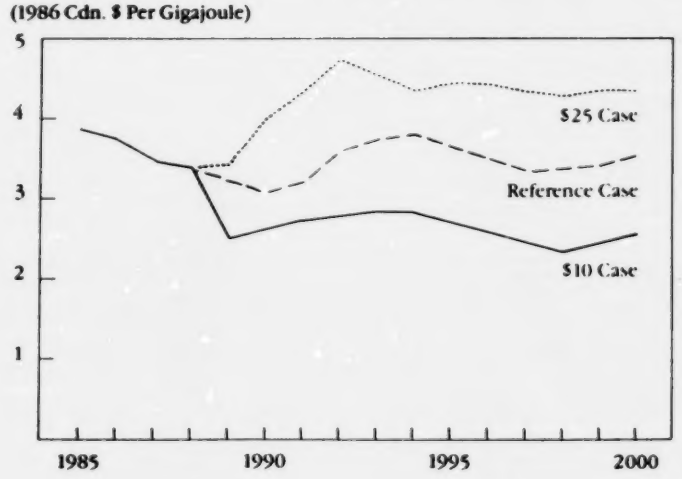
necessitating the addition of a significant amount of new commercial floorspace. This new floorspace will tend to be more reliant on space cooling, computers and other electricity-using activity, but will also be more energy-efficient in its lighting and equipment use.

Crude Oil Price Scenarios, 1985-2000

Price of West Texas Intermediate at Chicago



Toronto Wholesale Natural Gas Price Scenarios, 1985-2000



Residential Electricity Price Scenarios, Toronto, 1985-2000

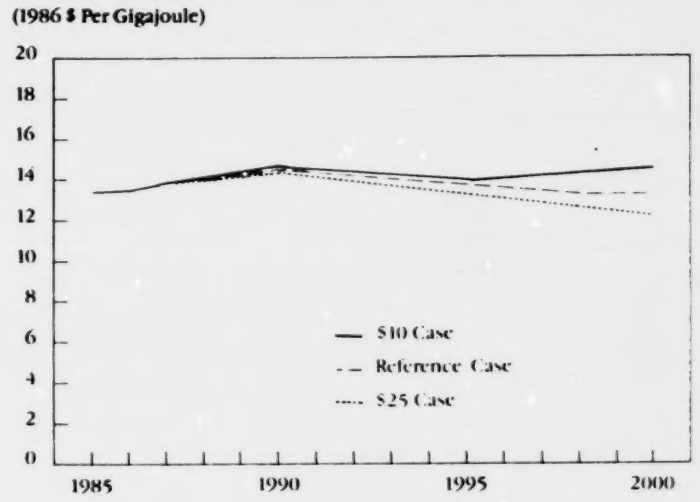


Table 10

Probable Range for Electricity Demand Growth, 1985-2000

(Annual Percentage Change)

Sectors	$25 Oil	Reference Case	$10 Oil	High Conservation	High Electricity Demand
Residential	0.9	1.1	1.6	0.1	2.6
Commercial	2.4	2.6	2.9	1.5	4.1
Industrial	2.4	2.9	3.2	2.4	3.4
All Sectors	2.0	2.3	2.7	1.4	3.4

Electricity Futures: A Comparison

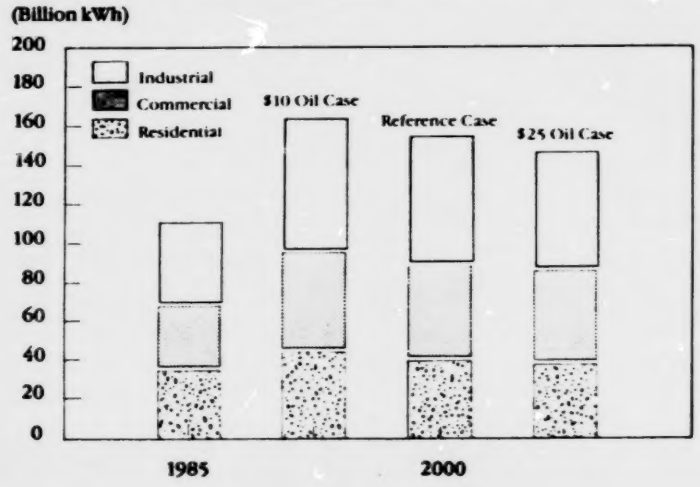
High Conservation vs. High Demand

Significant differences in the growth of electricity demand emerge when assumptions about the takeup of electricity conservation measures are varied. A major conservation effort through utility programs and government regulation could see electricity demand grow as little as 1.4 per cent annually for the 1985 to 2000 period. Alternatively, if the efficiency improvements envisaged in the Reference Case are not made and the economy becomes significantly more electricity-intensive, demand growth could be 3.4 per cent a year.

Sensitivity to Economic Growth Cases

For the three scenarios examined, Ontario economic growth for the 1985 to 2000 period could range from 2.8 to 3.6 per cent per annum. The corresponding range for electricity demand growth is 2.0 to 2.7 per cent a year, which represents cumulative growth over the period ranging from 35 to 50 per cent. In the Reference Case electricity use increases about 2.3 per cent annually, on average, with the result that by the year 2000, Ontario's electricity consumption would be 41 per cent above 1985 levels.

Electricity Use in the Oil Price Scenarios, 1985 and 2000



End-Use Energy

"**End-use energy**" is that which is consumed at the point of use, such as in furnaces, car engines, electric motors, lights, and industrial boilers. It also includes non-energy use – mainly crude oil used for petrochemical feedstocks and products such as lubricating oils, waxes and asphalt. The four major forms of end-use energy are petroleum products (such as gasoline), natural gas, electricity and coal.

"**Primary energy**" is the sum of end-use energy and the energy consumed in the production of end-use energy. This primarily consists of (1) the energy used in electricity generation, (2) the energy used to transform the raw energy form into usable products (such as in refining crude oil to produce petroleum products) and (3) the energy used and losses incurred to deliver energy to customers (such as transmitting and distributing natural gas or electricity).

Appendix: Ontario's Future Energy Demand

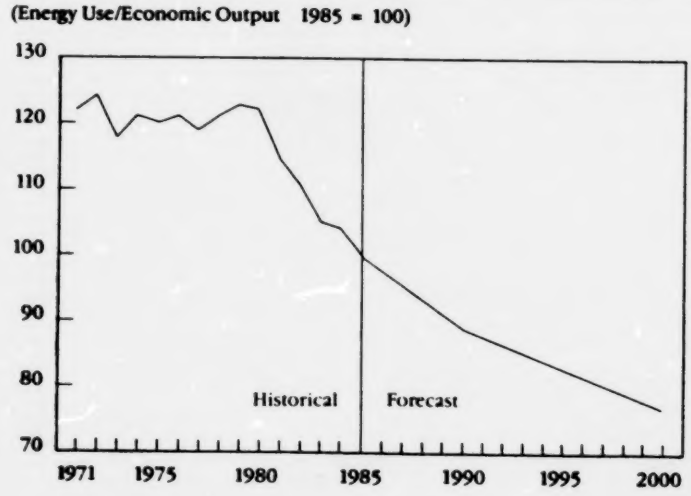
Reference Case

Total End-Use Energy Demand

Over the entire forecast period total end-use energy demand could grow at an average rate of 1.4 per cent, less than half that of the economy. On an intensity basis i.e., energy use per unit of output, the forecast level marks a considerable decrease from the peak levels that occurred in the 1970s. Energy intensity could decrease 20 to 25 per cent from the 1985 level by the year 2000.

Initially, energy use may expand 1.6 per cent a year driven by strong economic growth and low oil and gas prices. However, during the 1990s slower economic growth and rising energy prices could result in energy demand growth declining to a 1.2 per cent rate. Individual fuels are expected to experience significant differences in growth.

Energy Use in Relation to Economic Activity
Reference Case



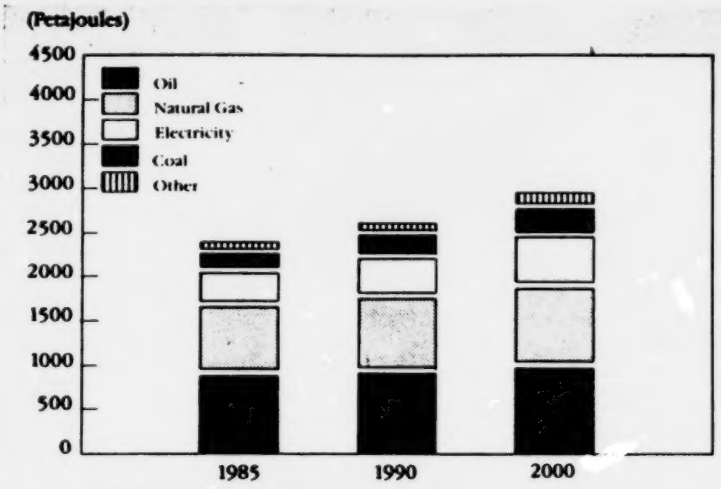
Explanation of Terms

A joule is a measure of work and energy in the SI system of units. A joule is the energy required to accelerate, at a constant rate of one metre per second per second, a mass of one kilogram over a distance of one metre.

A petajoule (PJ) is equal to one quadrillion (10^{15}) joules. One PJ is roughly equal to the amount of energy required to heat 10,000 homes for a year. Ontario consumes an average of 10 PJ of primary energy a day.

One PJ is equal to 278 million kWh, and 3.6 PJ are equal to one billion kWh. One PJ is equivalent to the energy contained in 164,000 barrels of oil or 26 million cubic metres of natural gas.

End-Use Energy by Fuel
Reference Case



Note: Natural Gas includes natural gas liquids.

Oil use, excluding petrochemical feedstock and other non-energy use, is expected to increase at 1.7 per cent a year between 1985 and 1990 stimulated by lower oil prices. Rising oil prices in the early 1990s could slow growth to a 0.2 per cent average annual rate. Over the full fifteen-year period annual growth would average 0.7 per cent. Increased use of natural gas liquids as a petrochemical feedstock will slow growth in overall oil end-use energy demand to an annual average of just over 0.4 per cent.

Natural gas consumption growth could follow a pattern similar to oil use. Between 1985 and 1990 growth could be 1.2 per cent a year. In the 1990s growth will likely fall off somewhat, but not as much as estimated for oil, due in part to the more moderate increase in natural gas prices. Over the full forecast period growth could average 1.1 per cent. The share of end-use energy held by natural gas would be virtually unchanged over the period.

Electricity is expected to continue to expand strongly in the late 1980s in response to high levels of economic growth. However, recent relative price increases for electricity will constrain the rate of growth. During the 1990s electricity's relative price will become more attractive but lower economic growth might result in an electricity demand growth of 2.1 per cent per year.

Natural gas liquids consumption, driven by increased use as a petrochemical feedstock and a transportation fuel, could expand by 3.3 per cent annually on average over the forecast period.

Table A1

Energy Consumption by Fuel and Sector, 1985
Reference Case

(Petajoules)

Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other	Total
Residential	68	216	11	—	130	18	443
Commercial	41	189	3	—	119	—	352
Industrial	75	300	6	213	153	68	815
Transportation	561	—	6	—	1	—	568
Non-Energy	183	—	20	—	—	—	203
Total	928	705	46	213	403	86	2 381

Note: Non-Energy includes petrochemical feedstock

Table A2

Energy Consumption by Fuel and Sector, 1990
Reference Case

(Petajoules)

Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other	Total
Residential	61	230	12	—	136	16	455
Commercial	30	198	3	—	138	2	371
Industrial	85	320	6	263	183	73	930
Transportation	633	1	12	—	1	—	647
Non-Energy	139	—	40	—	—	—	179
Total	948	749	73	263	458	91	2 582

Note: Non-Energy includes petrochemical feedstock

Table A3

Energy Consumption by Fuel and Sector, 2000
Reference Case

(Petajoules)

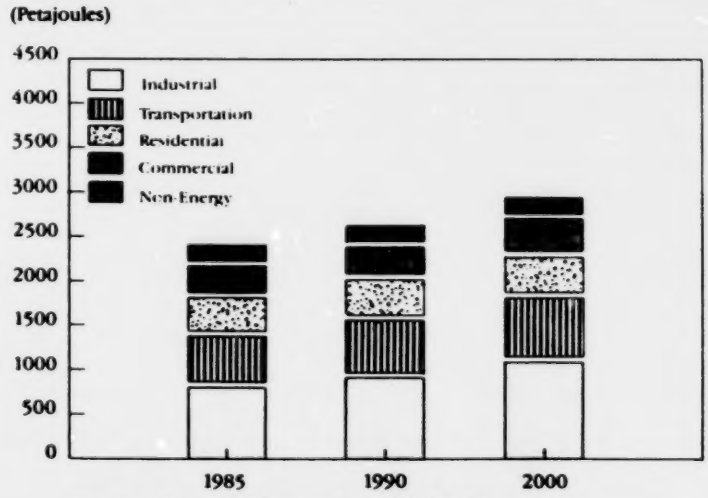
Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other	Total
Residential	49	222	11	—	153	19	454
Commercial	21	234	4	—	175	4	438
Industrial	92	370	8	322	236	99	1.127
Transportation	662	3	12	—	1	26	704
Non-Energy	167	—	40	—	—	—	207
Total	991	829	75	322	565	148	2.930

Note: Non-Energy includes petrochemical feedstock

Coal use will be determined largely by the strong growth in the iron and steel industry where coking coal is a key raw material and energy source. Some increase may occur in coal use by other industries but this fuel substitution could be limited by low oil and gas prices. Over the 1985 to 2000 period coal use could grow 2.5 to 3.0 per cent per year.

Other energy consumption consists primarily of wood waste and spent pulping liquor used by the pulp and paper industry, wood used for home heating, some solar heating in commercial buildings, and methanol used as a transportation fuel. Growth in the use of these fuels would slow in the first part of the period due in part to the low prices for oil and natural gas. As oil and natural gas prices increase, the consumption of other fuels should expand more quickly. By the end of the century they could account for just over 5 per cent of energy use, up from less than 4 per cent today.

End-Use Energy by Sector
Reference Case



Note: Non-Energy includes petrochemical feedstocks.

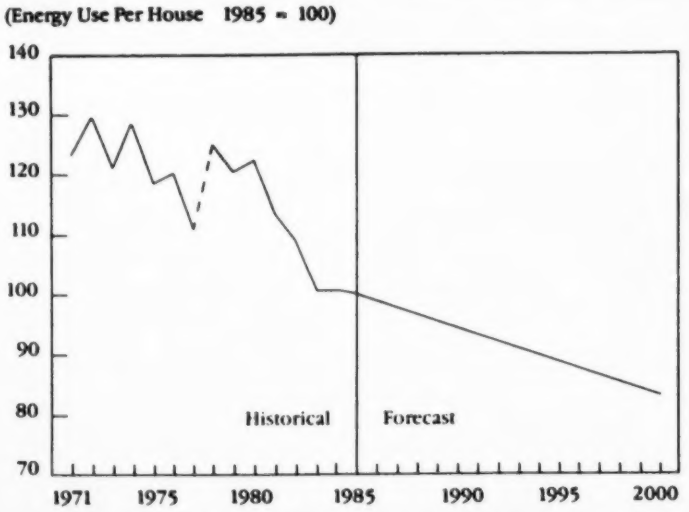
Sectoral Energy Use

Residential

As of 1986, energy use per household had declined about 25 per cent from the highs that occurred in the early 1970s. Although the housing stock may increase by almost 25 per cent, energy consumption could be flat in this sector as a result of efficiency gains from new construction, improved furnaces and housing retrofit. By the year 2000 residential energy intensity is expected to decline by 15 to 20 per cent from 1985 levels.

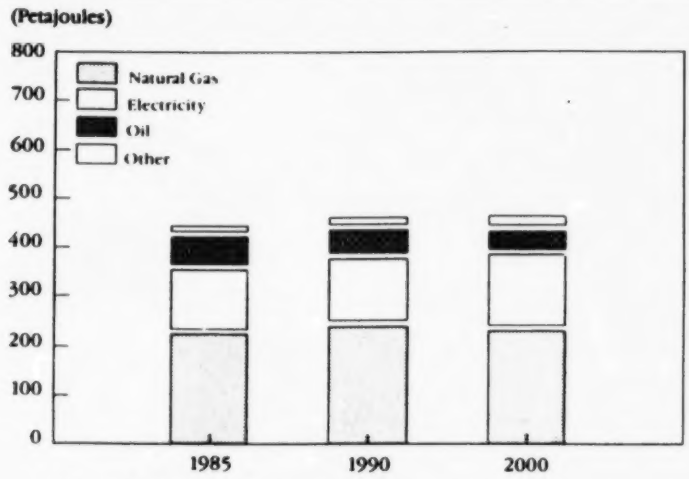
By the end of the forecast period, oil could account for 11 per cent of household energy use, down from 15 per cent today. Natural gas would increase its share slightly while the share held by electricity would increase from just under 30 per cent to just over one-third.

Residential Energy Use Per Household
Reference Case



Note: Change from 1977 to 1978 resulted from modifications to Statistics Canada methodology. Before 1978 apartments were included in the commercial sector.

Residential Energy Use by Fuel
Reference Case



Note: Natural Gas includes natural gas liquids.

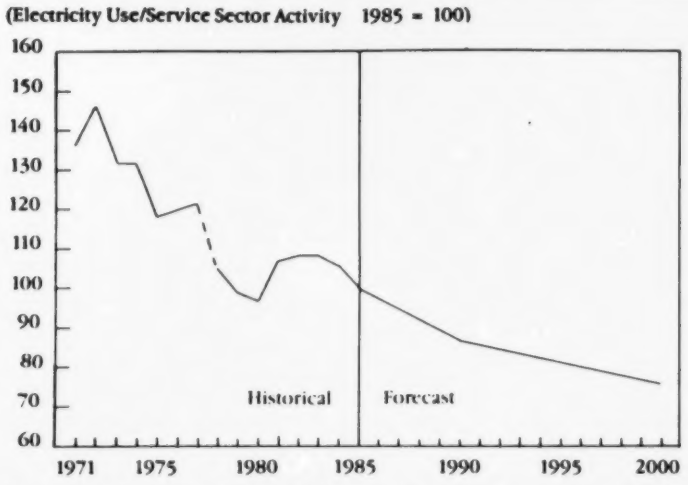
Commercial and Institutional

From an early 1970s peak, the intensity of energy use in this sector has declined even more rapidly than in the residential sector. Service sector activity could increase at an average annual rate of 3.4 per cent over the period. Since floorspace grows more slowly than business activity and significant efficiency gains are expected in heating and lighting, energy use could expand as little as 1.5 per cent on average. **Between 1985 and 2000 commercial sector energy intensity is projected to decline by almost 25 per cent.**

Oil could maintain its current 12 per cent share of energy use in the sector in the near term due to low oil prices. However, the oil price increases expected in the 1990s may cause this share to fall to 5 per cent by the year 2000.

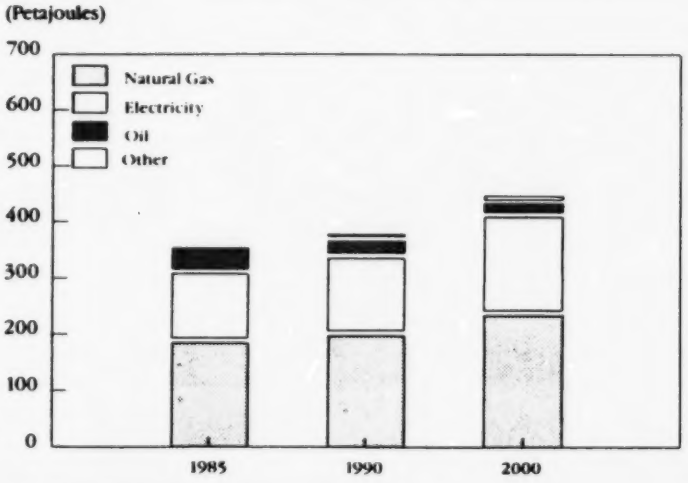
Natural gas would continue to account for over half the energy used in this sector and increase its share slightly over the period. Electricity consumption would increase more rapidly than the use of other fuels. By the turn of the century it could account for 40 per cent of energy use compared to just over one-third in 1985. Other energy sources, primarily solar-assisted water heating, might account for a small amount of energy use during the latter part of the period.

Commercial Energy Use Relative to Service Sector Activity
Reference Case



Note: Change from 1977 to 1978 resulted from modifications to Statistics Canada methodology. Since 1978 apartments have been included in the residential sector; previously they were included in the commercial sector.

Commercial Energy Use by Fuel
Reference Case



Note: Natural Gas includes natural gas liquids.

Industrial

Energy use by industry would likely increase at a faster rate over the period than in the other sectors. However, at 2.2 per cent per annum on average, it would be significantly slower than the expected increase in industrial output. This represents a major improvement in energy efficiency in light of the energy-intensive nature of Ontario industrial production and the substantial level of efficiency improvements already made. **As of 1985, energy intensity in this sector had declined approximately 23 per cent from the 1979 peak. This is expected to decline a further 9 per cent by the end of the century.**

Oil is more price competitive in the industrial sector, therefore its energy use would only decline slightly by the end of the period.

Natural gas could suffer a decline in its share of industrial energy use due to rising prices and the large potential for efficiency improvements in many high temperature process heating applications. As a result, natural gas could account for one-third of energy use in the year 2000, down from 37 per cent in 1985.

Electricity would likely be the fastest growing major energy source in the industrial sector due to the more electricity-intensive nature of newer production processes. However, reduced price competitiveness could limit penetration into process heating applications. By the year 2000 electricity is expected to account for 21 per cent of industrial energy use, up from 19 per cent in 1985.

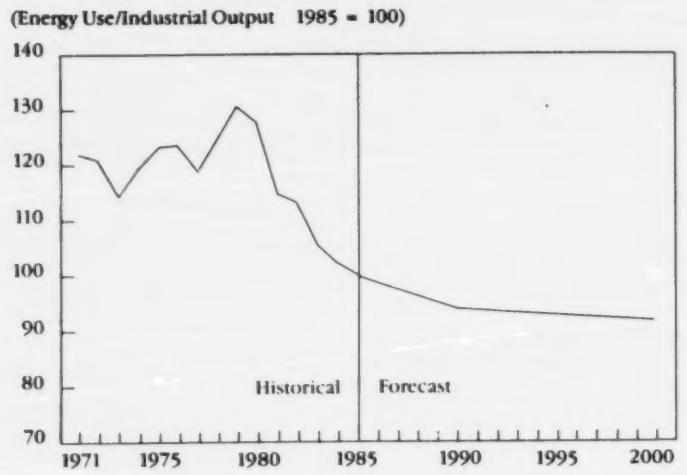
Coal use could increase strongly, particularly in the near term, because of strong output growth in the iron and steel industry. Coking coal is a primary energy source and raw material in the production of steel. Thermal coal use in other industries would expand somewhat but this will be constrained by low oil and gas prices.

Other energy use, primarily wood waste and spent pulping liquor, could grow in line with output growth in the pulp and paper industry. New pulping processes which make more efficient use of wood and reduce the need for chemicals could limit the use of these fuels.

Petrochemical feedstock and other non-energy use may increase only very slowly over the period. The ability of the petrochemical industry to use both natural gas liquids and oil as feedstock will greatly reduce overall requirements. Oil-based feedstocks can be replaced by natural gas liquids with two-thirds or less of the energy value. Oil consumption for other non-energy uses such as asphalts and oils and greases will be driven by construction activity and transportation requirements.

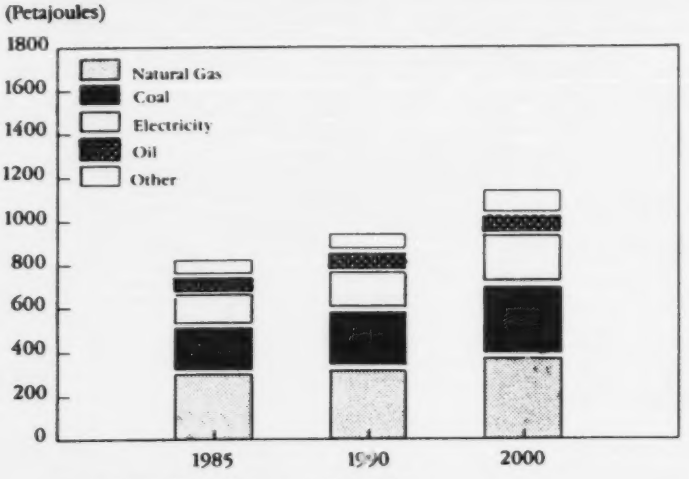
Energy Use Relative to Industrial Output

Reference Case



Industrial Energy Use by Fuel

Reference Case



Note: Natural Gas includes natural gas liquids.

Table A4

Energy Use Growth by Fuel and Sector, 1985-2000

Reference Case

A. Annual Growth (Per Cent Per Annum)

Oil	0.4	Residential	0.2
Natural Gas	1.1	Commercial	1.5
Natural Gas Liquids	3.3	Industrial	2.2
Electricity	2.3	Transportation	1.4
Coal	2.8	Non-Energy	-0.2
Other	3.7		
All Fuels	1.4	All Sectors	1.4

B. Cumulative Increase (Per Cent)

Oil	6.8	Residential	2.5
Natural Gas	17.6	Commercial	24.4
Natural Gas Liquids	63.0	Industrial	23.9
Electricity	40.2	Transportation	38.3
Coal	51.2	Non-Energy	2.0
Other	72.1		
All Fuels	23.1	All Sectors	23.1

Note: Non-Energy includes petrochemical feedstock.

Table A5

Fuel Shares, 1985

Reference Case

(Per Cent)

Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other
Residential	15.4	48.8	2.5	—	29.3	4.0
Commercial	11.6	53.7	0.9	—	33.8	—
Industrial	9.2	36.8	0.7	26.1	18.8	8.4
Transportation	98.7	—	1.1	—	0.2	—
Non-Energy	90.1	—	9.9	—	—	—
All Sectors	39.0	29.6	1.9	8.9	16.9	3.7

Note: Non-Energy includes petrochemical feedstock.

Transportation

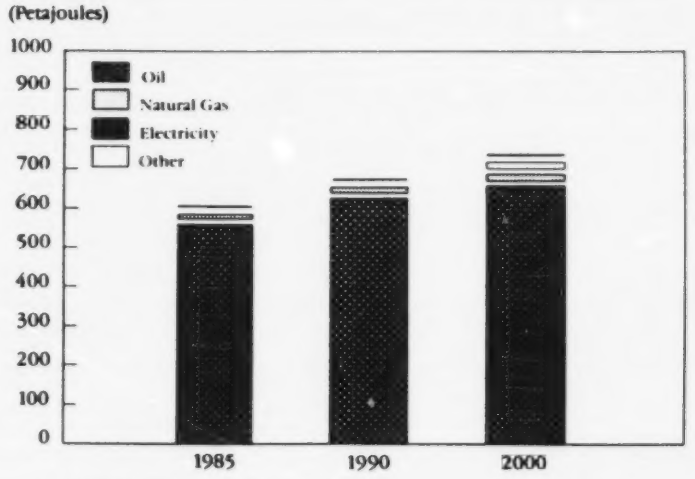
Energy use in the transportation sector could grow at a fairly strong 2.6 per cent rate in the 1985 to 1990 period, declining sharply to less than 1.0 per cent per annum in the 1990s as oil prices rise and economic and population growth slows. Over the full period, growth in energy use could average 1.4 per cent annually.

Oil would continue to account for the vast majority of energy used in this sector. However, the increased use of other fuels would reduce oil's share from almost 99 per cent of energy use in 1985 to 94 per cent in the year 2000.

The use of propane as a transportation fuel could double over the period, accounting for almost 2.0 per cent of transportation energy use by the year 2000. Natural gas could increase its use over the period, but along with electricity would remain a minor fuel in this sector. Methanol (which is produced primarily from natural gas) could become increasingly important both as an octane enhancer and as a straight fuel. By the year 2000 it could account for almost 4.0 per cent of transportation energy use.

Transportation Energy Use by Fuel

Reference Case



Note: Natural Gas includes natural gas liquids.

Table A6

Fuel Shares, 2000
Reference Case

(Per Cent)

Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other
Residential	10.8	48.9	2.4	—	35.*	4.2
Commercial	4.8	55.4	0.9	—	40.0	0.9
Industrial	8.2	32.8	0.*	28.6	20.9	8.8
Transportation	94.0	0.4	1.*	—	0.2	3.*
Non-Energy	80.*	—	19.3	—	—	—
All Sectors	33.8	28.3	2.6	11.0	19.3	5.0

Note: Non-Energy includes petrochemical feedstock.

Table A7

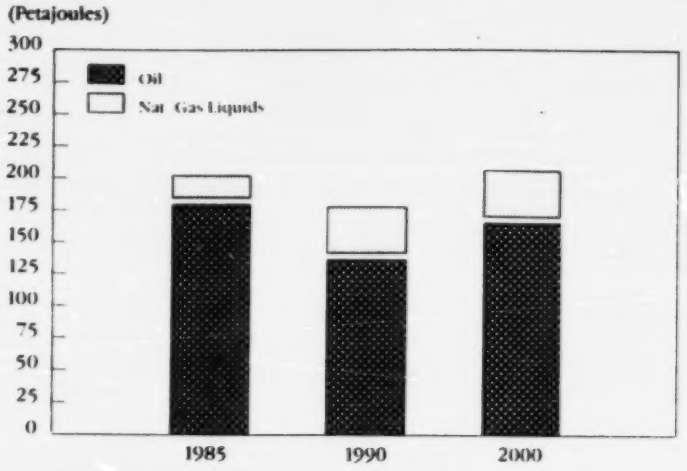
Energy Consumption by Fuel and Sector, 2000
$25 Oil Scenario

(Petajoules)

Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other	Total
Residential	44	215	12	—	149	1*	43*
Commercial	16	22*	4	—	1*1	4	422
Industrial	8*	344	*	312	218	8*	1,055
Transportation	582	6	14	—	1	23	626
Non-Energy	162	—	40	—	—	—	202
Total	891	*92	**	312	539	131	2,*42

Note: Non-Energy includes petrochemical feedstock.

Non-Energy Use by Fuel
Reference Case



Note: Non-Energy includes petrochemical feedstock.

$25 Oil Scenario

With world oil prices around $25 U.S. during the 1990s, energy use could expand at 1.0 per cent per year on average over the 1985 to 2000 period, less than two-fifths the rate of economic growth.

Fuel Use

- Oil use would decline slowly at 0.3 per cent a year in response to rising oil prices and a deteriorating competitive position relative to gas and electricity.
- Natural gas use is expected to grow 0.8 per cent a year on average, as slow economic growth and rising natural gas prices are partly offset by an improving competitive position versus oil.
- Coal use could expand 2.6 per cent per year as low growth in iron and steel output is partly offset by the increasing attractiveness of coal in other industries.
- Electricity growth is forecast to be about 2.0 per cent annually on average because of low economic growth and a relatively pessimistic investment outlook.
- Other energy use could grow just under 3.0 per cent a year. Rising oil and gas prices would encourage the use of other fuels but slow economic growth will tend to reduce their adoption.

Table A8

Demand Growth and Fuel Shares
$25 Oil Scenario

	Demand Growth (Per Cent Per Annum) 1985-2000	Fuel Shares (Per Cent) 1985	2000
Oil	-0.3	39	32
Natural Gas	0.8	30	29
Natural Gas Liquids	3.5	2	3
Coal	2.6	9	11
Electricity	2.0	17	20
Other	2.8	3	5
All Fuels	1.0	100	100

Table A9

Energy Consumption by Fuel and Sector, 2000
$10 Oil Scenario

(Petajoules)

Sector	Oil	Natural Gas	Natural Gas Liquids	Coal	Electricity	Other	Total
Residential	58	241	13	—	166	17	495
Commercial	43	231	4	—	183	4	465
Industrial	100	415	8	364	247	103	1,237
Transportation	769	1	11	—	1	8	790
Non-Energy	171	—	50	—	—	—	221
Total	1,141	888	86	364	597	132	3,208

Note: Non-Energy includes petrochemical feedstock.

Sectoral Energy Use

- **Residential** energy consumption could remain flat or decline slightly over the period in response to rising oil and gas prices and lower personal income growth.
- **Commercial and institutional** building energy use could grow at a 1.2 per cent annual rate. Service sector activity could grow at just over 3.0 per cent a year.
- **Industrial** energy use may expand 1.7 per cent a year in response to slow growth in output (2.5 per cent a year) and rising prices.
- **Transportation** energy use would average 0.7 per cent growth per annum. Low growth in personal income and rising prices act to restrain travel and to encourage the use of more efficient vehicles. In addition, lower rates of growth in overall economic activity will reduce the growth in freight shipments.

$10 Oil Scenario

With world oil prices around $10 U.S., energy use could grow at an annual average of 2.0 per cent over the 1985 to 2000 period, about three-fifths of the rate of growth in the economy.

Fuel Use

- Oil use is forecast to grow 1.4 per cent a year in response to low prices. Nevertheless, the share of end-use energy held by oil would decline from 39 per cent in 1985 to 35 per cent by the year 2000.
- **Natural gas** use could increase 1.6 per cent annually in response to low gas prices and high economic growth. By 2000 it would account for 28 per cent of end-use energy.
- **Coal** use is expected to grow 3.6 per cent per year due to strong growth in iron and steel industry output. Coal penetration in other industries is constrained by low oil and gas prices.
- **Electricity** use could increase 2.7 per cent a year as higher economic growth is partially offset by strong competition from oil and gas. Electricity would account for 19 per cent of end-use energy in 2000, up slightly from current levels.
- **Other energy** use may expand 2.9 per cent per year primarily due to the expansion of the pulp and paper industry. Penetration of other fuels would be limited by low prices for conventional fuels.

Table A10

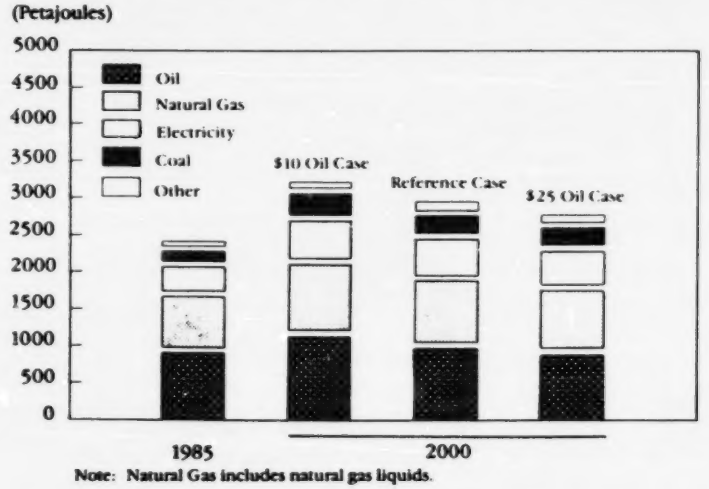
Demand Growth Rates and Fuel Shares
$10 Oil Scenario

	Demand Growth (Per Cent Per Annum) 1985-2000	Fuel Shares (Per Cent) 1985	2000
Oil	1.4	39	35
Natural Gas	1.6	30	28
Natural Gas Liquids	4.3	2	3
Coal	3.6	9	11
Electricity	2.7	17	19
Other	2.9	3	4
All Fuels	2.1	100	100

Sectoral Energy Use

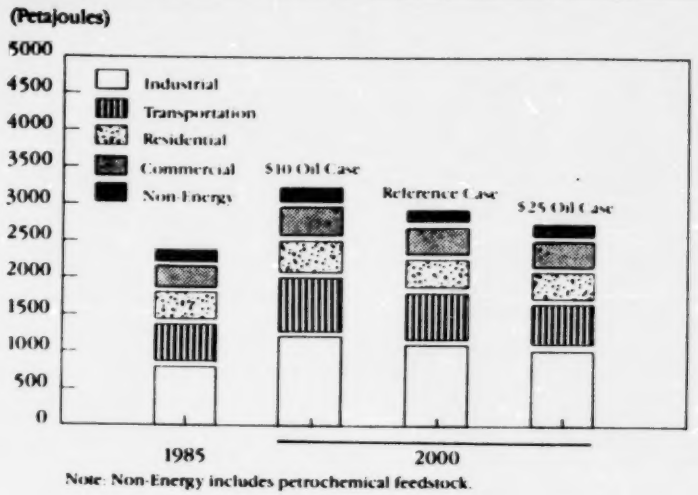
- **Residential** energy use could grow 0.7 per cent a year on average as low oil and gas prices reduce the incentive for conservation and efficiency improvements.
- **Commercial and institutional** building energy use could expand 1.9 per cent a year as service sector output would grow at a strong 4.0 per cent annual rate.
- **Industrial** energy use could expand 2.8 per cent a year, still significantly below the growth in industrial output of 3.2 per cent.
- **Transportation** energy use could increase 2.2 per cent a year in response to higher personal incomes, greater economic activity and low gasoline prices.

Energy Use in the Three Cases, By Fuel



Note: Natural Gas includes natural gas liquids.

Energy Use in the Three Cases, By Sector



Note: Non-Energy includes petrochemical feedstock.

Table A11

Energy Growth and Economic Growth, 1985-2000: A Comparison of Cases

(Per Cent Per Annum)

	Energy Growth	Economic Growth	Ratio
$25 Oil Case	1.0	2.8	0.35
Reference Case	1.4	3.2	0.44
$10 Oil Case	2.0	3.6	0.56

Energy Futures

Sensitivity to Economic Growth Cases

For the three scenarios examined, Ontario economic growth could range from 2.8 to 3.6 per cent annually over the forecast period. In the $25 Oil Case, due in part to higher prices, energy demand grows at only one-third the rate of economic growth. In the $10 Oil Case, with oil prices remaining low over the period, energy growth would be almost three-fifths the economic growth rate. Energy growth in the Reference Case would be between two-fifths and one-half the growth in the economy.